

WHAT IS CLAIMED IS:

1. A chemical-mechanical polishing system comprising:
 - (a) an abrasive and/or polishing pad,
 - (b) boric acid, or a conjugate base thereof, and
 - (c) an aqueous carrier,

wherein the boric acid and conjugate base are not present together in the polishing system in a sufficient amount to act as a pH buffer.

2. The chemical-mechanical polishing system of claim 1, wherein the abrasive is a metal oxide.

3. The chemical-mechanical polishing system of claim 2, wherein the abrasive is selected from the group consisting of alumina, silica, titania, ceria, zirconia, germania, magnesia, co-formed products thereof, and combinations thereof.

4. The chemical-mechanical polishing system of claim 3, wherein the abrasive is alumina or silica.

5. The chemical-mechanical polishing system of claim 1, wherein the abrasive is fixed on a polishing pad.

6. The chemical-mechanical polishing system of claim 1, wherein the abrasive is in particulate form and is suspended in the carrier.

7. The chemical-mechanical polishing system of claim 1, wherein the carrier is water.

8. The chemical-mechanical polishing system of claim 1, wherein the system further comprises an oxidizing agent.

9. The chemical-mechanical polishing system of claim 8, wherein the oxidizing agent is a peroxide or persulfate.

10. The chemical-mechanical polishing system of claim 1, wherein the system further comprises a film-forming agent.

11. The chemical-mechanical polishing system of claim 10, wherein the film-forming agent is an azole.

12. The chemical-mechanical polishing system of claim 1, wherein the system comprises about 0.5 wt.% or more carrier-suspended abrasive particles, about 0.01 wt.% or more boric acid or conjugate base thereof, and water.

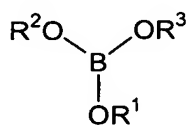
13. The chemical-mechanical polishing system of claim 1, wherein the system further comprises a complexing agent.

14. A chemical-mechanical polishing system comprising:

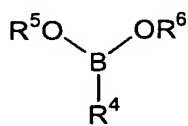
(a) an abrasive and/or polishing pad,

(b) an aqueous carrier, and

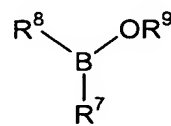
(c) a water-soluble boron-containing compound that is not boric acid, or salt thereof, formula I-VII:



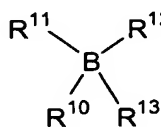
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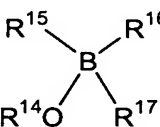
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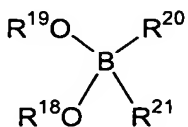
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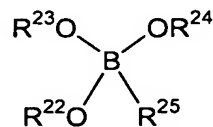
IV



V



VI



VII

wherein,

$\text{R}^1, \text{R}^2, \text{R}^3, \text{R}^5, \text{R}^6, \text{R}^9, \text{R}^{14}, \text{R}^{18}, \text{R}^{19}, \text{R}^{22}, \text{R}^{23},$ and R^{24} are independently selected from the group consisting of H, C_{1-20} alkyl, C_{6-30} aryl including polycyclic aryl,

cyclo(C₃₋₂₀)alkyl, hetero(C₆₋₃₀)aryl including polycyclic heteroaryl, C₃₋₂₀ heterocyclyl, C₂₋₂₀ alkenyl, and C₂₋₂₀ alkynyl,

R⁴, R⁷, R⁸, R¹⁰, R¹¹, R¹², R¹³, R¹⁵, R¹⁶, R¹⁷, R²⁰, R²¹, and R²⁵ are independently selected from the group consisting of H, halide, C₁₋₂₀ alkyl, C₆₋₃₀ aryl including polycyclic aryl, cyclo(C₃₋₂₀)alkyl, hetero(C₆₋₃₀)aryl including polycyclic heteroaryl, C₃₋₂₀ heterocyclyl, C₂₋₂₀ alkenyl, and C₂₋₂₀ alkynyl,

any two R substituents of a formula can be linked through 1-16 atoms selected from the group consisting of C, N, O, and S to form a cyclic ring, and

R¹-R²⁵ are optionally substituted with 1-5 substituents independently selected from the group consisting of halide, C₁₋₂₀ alkyl, C₁₋₂₀ alkoxy, thio(C₁₋₂₀)alkyl, C₆₋₃₀ aryl including polycyclic aryl, C₆₋₃₀ ar(C₁₋₂₀)alkyl, C₆₋₃₀ ar(C₁₋₂₀)alkoxy, thio(C₆₋₃₀)aryl, cyclo(C₁₋₂₀)alkyl, cyclo(C₃₋₂₀)alkyloxy, hetero(C₆₋₃₀)aryl including polycyclic heteroaryl, C₃₋₂₀ heterocyclyl, heterocyclo(C₃₋₂₀)alkyloxy, C₂₋₂₀ alkenyl, C₂₋₂₀ alkynyl, B(OH)(C₁₋₂₀ alkyl), B(OH)(cyclo(C₁₋₂₀)alkyl), B(OH)(C₆₋₃₀ aryl), B(OH)(C₆₋₃₀ heteroaryl), B(OH)₂, thiol, hydroxy, halo(C₁₋₂₀)alkyl, halo(C₁₋₂₀)alkoxy, nitro, amino, C₁₋₂₀ alkylamino, di(C₁₋₂₀)alkylamino, amino(C₁₋₂₀)alkyl, C₁₋₂₀alkylamino(C₁₋₂₀)alkyl, nitrile, cyano, carbonyl, C₁₋₂₀ alkylcarbonyl, carboxy, carboxy(C₁₋₂₀)alkyl, silyl, and siloxy.

15. The chemical-mechanical polishing system of claim 14, wherein the water-soluble boron-containing compound is a trialkylborate.

16. The chemical-mechanical polishing system of claim 14, wherein the water-soluble boron-containing compound is a borinic acid, boronic acid, borinate ester, or boronate ester.

17. The chemical-mechanical polishing system of claim 14, wherein the water-soluble boron-containing compound is a benzodioxaborole compound.

18. The chemical-mechanical polishing system of claim 17, wherein the water-soluble boron-containing compound is *B*-bromocatecholborane.

19. The chemical-mechanical polishing system of claim 14, wherein the water-soluble boron-containing compound is a tetraarylborate salt.
20. The chemical-mechanical polishing system of claim 14, wherein the water-soluble boron-containing compound is generated *in situ*.
21. The chemical-mechanical polishing system of claim 14, wherein the abrasive is a metal oxide.
22. The chemical-mechanical polishing system of claim 21, wherein the abrasive is selected from the group consisting of alumina, silica, titania, ceria, zirconia, germania, magnesia, co-formed products thereof, and combinations thereof.
23. The chemical-mechanical polishing system of claim 22, wherein the abrasive is alumina or silica.
24. The chemical-mechanical polishing system of claim 14, wherein the abrasive is fixed on a polishing pad.
25. The chemical-mechanical polishing system of claim 14, wherein the abrasive is in particulate form and is suspended in the carrier.
26. The chemical-mechanical polishing system of claim 14, wherein the carrier is water.
27. The chemical-mechanical polishing system of claim 14, wherein the system further comprises an oxidizing agent.
28. The chemical-mechanical polishing system of claim 27, wherein the oxidizing agent is a peroxide or persulfate.

29. The chemical-mechanical polishing system of claim 14, wherein the system further comprises a film-forming agent.

30. The chemical-mechanical polishing system of claim 29, wherein the film-forming agent is an azole.

31. The chemical-mechanical polishing system of claim 14, wherein the system comprises about 0.5 wt.% or more carrier-suspended abrasive particles, about 0.01 wt.% or more water-soluble boron-containing compound or salt thereof, and water.

32. The chemical-mechanical polishing system of claim 31, wherein the abrasive particles are alumina or silica particles, and the water-soluble boron-containing compound is a trialkylborate, borinic acid, boronic acid, borinate ester, or boronate ester.

33. The chemical-mechanical polishing system of claim 14, wherein the system further comprises a complexing agent.

34. A method of polishing a substrate comprising:

(i) contacting a substrate with a chemical-mechanical polishing system comprising:

- (a) an abrasive and/or polishing pad,
- (b) boric acid, or conjugate base thereof, and
- (c) an aqueous carrier,

wherein the boric acid and conjugate base are not present together in the polishing system in a sufficient amount to act as a pH buffer, and

(ii) abrading at least a portion of the substrate to polish the substrate.

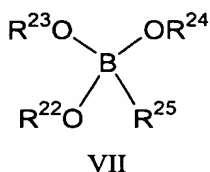
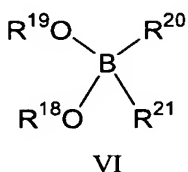
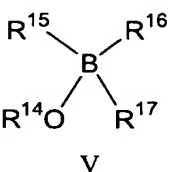
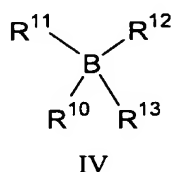
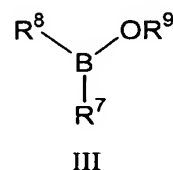
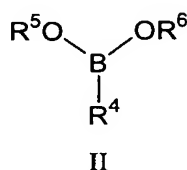
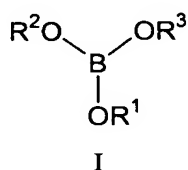
35. The method of claim 34, wherein the substrate comprises a metal oxide layer and a metal layer.

36. The method of claim 35, wherein the metal layer comprises copper, tungsten, tantalum, or titanium.

37. A method of polishing a substrate comprising:

(i) contacting a substrate with a chemical-mechanical polishing system comprising:

- (a) an abrasive and/or polishing pad,
- (b) an aqueous carrier, and
- (c) a water-soluble boron-containing compound that is not boric acid, or salt thereof, of formula I-VII:



wherein,

$\text{R}^1, \text{R}^2, \text{R}^3, \text{R}^5, \text{R}^6, \text{R}^9, \text{R}^{14}, \text{R}^{18}, \text{R}^{19}, \text{R}^{22}, \text{R}^{23}$, and R^{24} are independently selected from the group consisting of H, C_{1-20} alkyl, C_{6-30} aryl including polycyclic aryl, cyclo(C_{3-20})alkyl, hetero(C_{6-30})aryl including polycyclic heteroaryl, C_{3-20} heterocyclyl, C_{2-20} alkenyl, and C_{2-20} alkynyl,

$\text{R}^4, \text{R}^7, \text{R}^8, \text{R}^{10}, \text{R}^{11}, \text{R}^{12}, \text{R}^{13}, \text{R}^{15}, \text{R}^{16}, \text{R}^{17}, \text{R}^{20}, \text{R}^{21}$, and R^{25} are independently selected from the group consisting of H, halide, C_{1-20} alkyl, C_{6-30} aryl including polycyclic aryl, cyclo(C_{3-20})alkyl, hetero(C_{6-30})aryl including polycyclic heteroaryl, C_{3-20} heterocyclyl, C_{2-20} alkenyl, and C_{2-20} alkynyl,

any two R substituents of a formula can be linked through 1-16 atoms selected from the group consisting of C, N, O, and S to form a cyclic ring, and

R^1 - R^{25} are optionally substituted with 1-5 substituents independently selected from the group consisting of halide, C_{1-20} alkyl, C_{1-20} alkoxy, thio(C_{1-20})alkyl, C_{6-30} aryl including polycyclic aryl, C_{6-30} ar(C_{1-20})alkyl, C_{6-30} ar(C_{1-20})alkoxy, thio(C_{6-30})aryl, cyclo(C_{1-20})alkyl, cyclo(C_{3-20})alkyloxy, hetero(C_{6-30})aryl including polycyclic heteroaryl, C_{3-20} heterocyclyl, heterocyclo(C_{3-20})alkyloxy, C_{2-20} alkenyl, C_{2-20}

alkynyl, B(OH)(C₁₋₂₀ alkyl), B(OH)(cyclo(C₁₋₂₀)alkyl), B(OH)(C₆₋₃₀ aryl), B(OH)(C₆₋₃₀ heteroaryl), B(OH)₂, thiol, hydroxy, halo(C₁₋₂₀)alkyl, halo(C₁₋₂₀)alkoxy, nitro, amino, C₁₋₂₀ alkylamino, di(C₁₋₂₀)alkylamino, amino(C₁₋₂₀)alkyl, C₁₋₂₀alkylamino(C₁₋₂₀)alkyl, nitrile, cyano, carbonyl, C₁₋₂₀ alkylcarbonyl, carboxy, carboxy(C₁₋₂₀)alkyl, silyl, and siloxy, and

(ii) abrading at least a portion of the substrate to polish the substrate.

38. The method of claim 37, wherein the substrate comprises a metal oxide layer and a metal layer.

39. The method of claim 38, wherein the metal layer comprises copper, tungsten, tantalum, or titanium.

40. The method of claim 37, wherein the water-soluble boron-containing compound is trialkylborate.

41. The method of claim 37, wherein the water-soluble boron-containing compound is a borinic acid, boronic acid, borinate ester, or boronate ester.

42. The method of claim 37, wherein the water-soluble boron-containing compound is a benzodioxoborole compound.

43. The method of claim 42, wherein the water-soluble boron-containing compound is *B*-bromocatecholborane.

44. The method of claim 37, wherein the water-soluble boron-containing compound is a tetraarylborate salt.